

Status of $Re(\epsilon'/\epsilon)$ – charged mode.

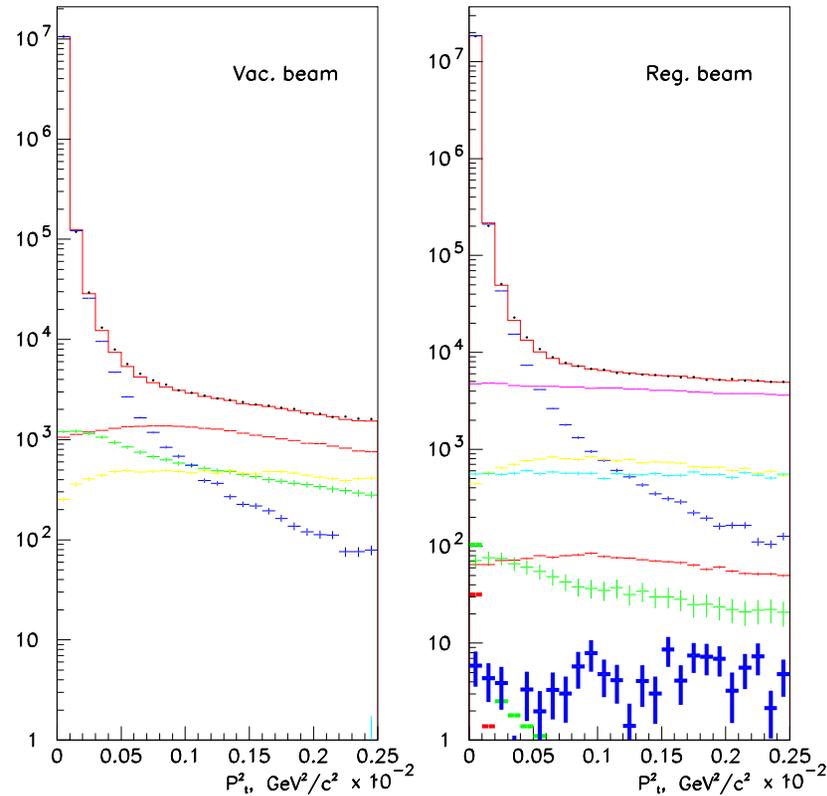
- BG subtraction
- Z overlays (and $Ke3$)
- Systematic uncertainties
- 99 effective regenerator edge.
- Kaon system parameter fits

Background Subtraction

Source	Background level, %					
	97 PRD		97		99	
	Vac	Reg	Vac	Reg	Vac	Reg
$Ke3$	0.036	0.001	0.032	0.001	0.032	0.001
$K\mu3$	0.054	0.002	0.034	0.001	0.030	0.001
Collimator scattering	0.010	0.010	0.009	0.009	0.008	0.008
Regenerator scattering	—	0.074	—	0.073	—	0.075
Total background	0.100	0.087	0.074	0.083	0.070	0.085

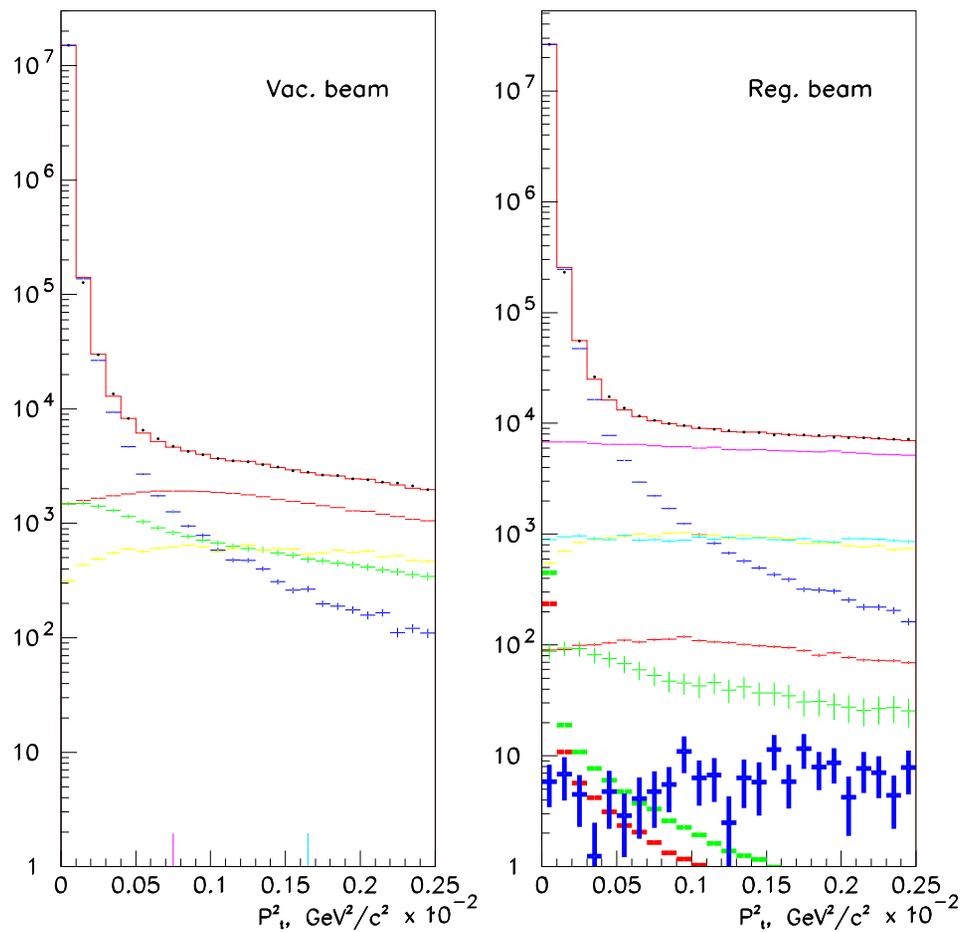
- More BG sources: junk production at regenerator ($\Delta \rightarrow p\pi$, $K^* \rightarrow K^\mp \pi^\pm$, $K^* \rightarrow K_S \pi^0$. – help to describe $m(\pi\pi)$ distribution.
- Separation of $Ke3$, $K\mu3$ based on CsI response. $K\mu3$ background is normalized first vs p_μ .
- Background sources are normalized in 10 GeV E_K bins.

BG: P_{\perp} plots for 97 data



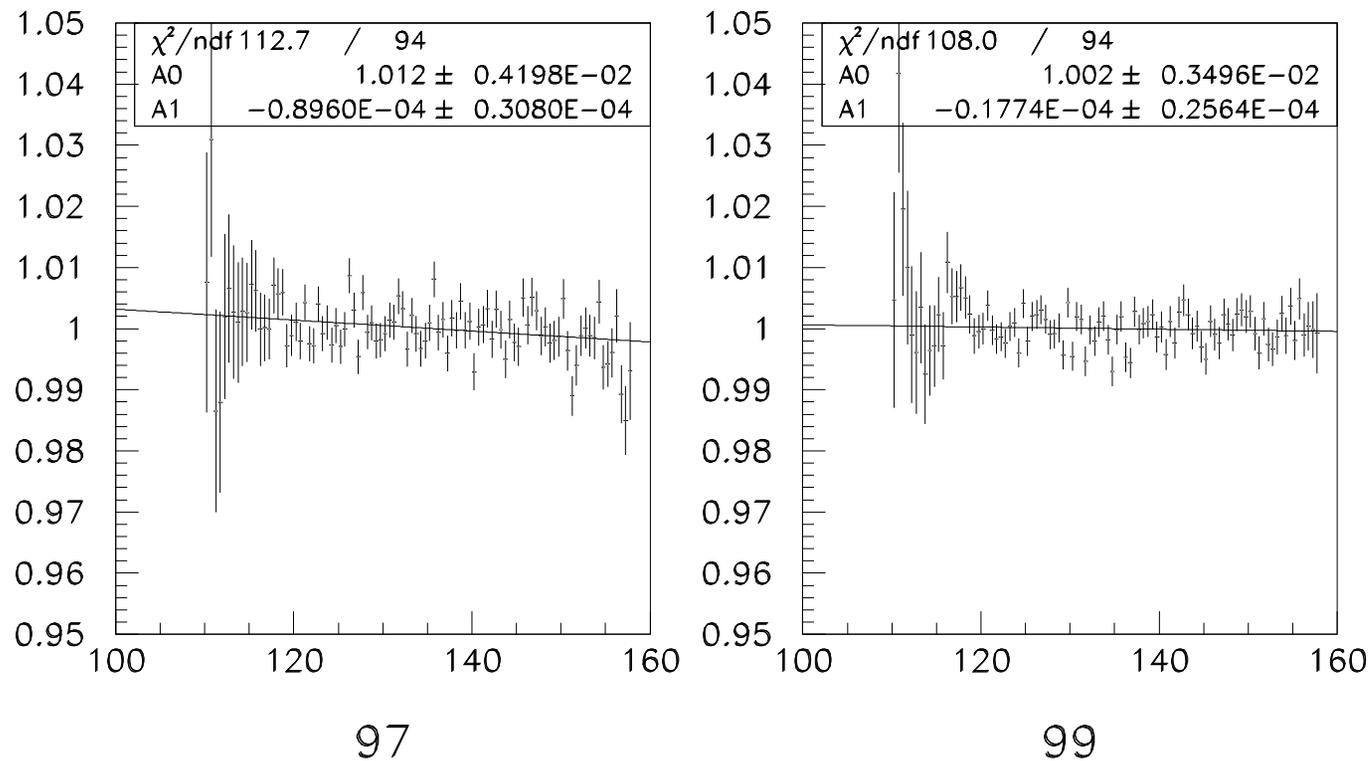
Dots – data, red line – sum of all MC, blue – signal MC, pink – diffractive reg. scat, red – $Ke3$, green – $K\mu3$, yellow – Col. Scattering. Light blue – inelastic reg. scat.

BG: P_{\perp} plots for 99 data



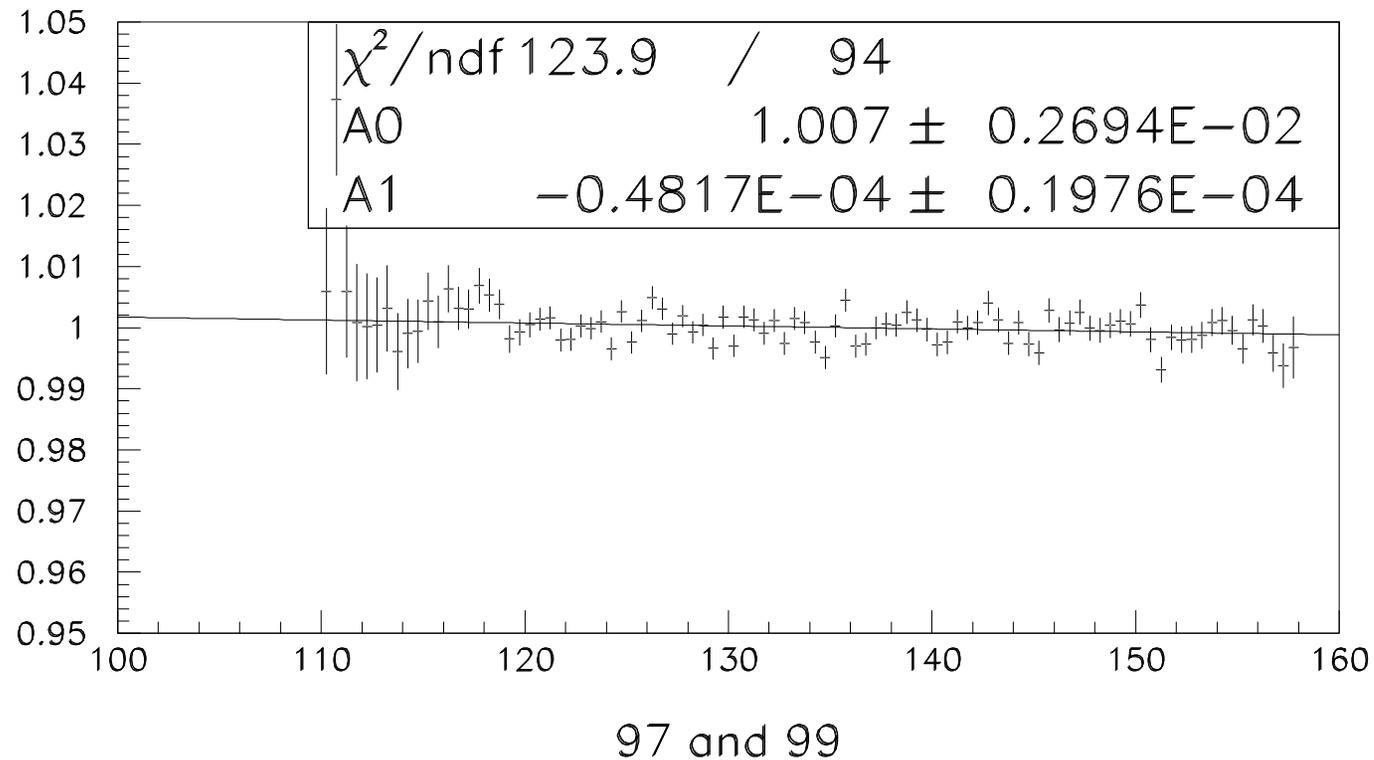
Mass side bands — later in the talk

Z slopes



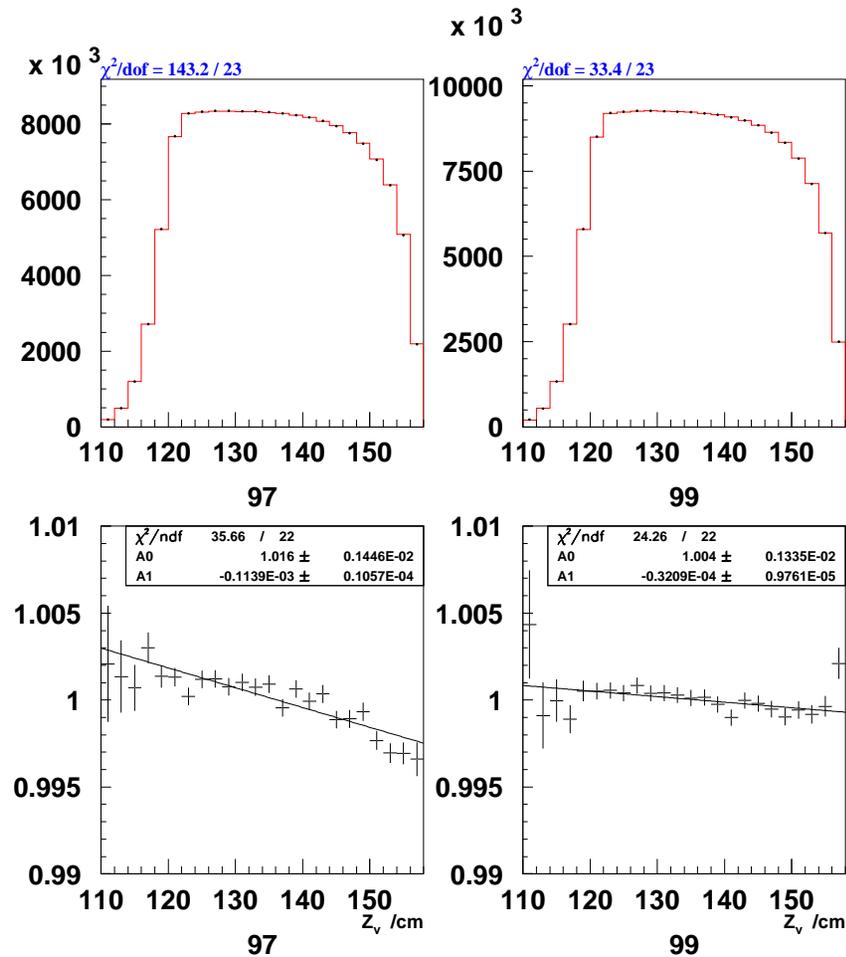
97 slope got worse vs PRD (0.9 vs 0.7). No slope for 99.

Combined Z slope



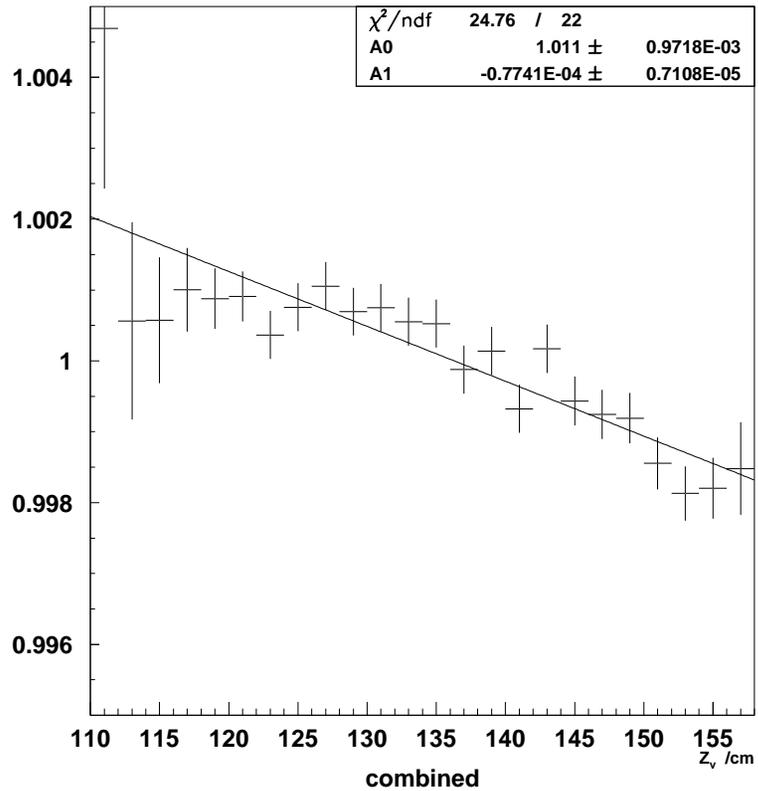
2.5σ significant Z slope ... 0.6×10^{-4} systematic uncertainty in $\text{Re}(\epsilon'/\epsilon)$.

Ke3 Z slopes



Compared to PRD, use VUS-like $Ke3$ selection (cut on E_{low} and E_{high}) 97 slope got much worse vs PRD (1.0 vs 0.0).

Combined $Ke3$ Z slope



	PRD	97	99	97-99
$\pi\pi$	-0.70 ± 0.30	-0.89 ± 0.31	-0.18 ± 0.25	-0.48 ± 0.20
$Ke3$	$+0.03 \pm 0.20$	-1.13 ± 0.11	-0.32 ± 0.10	-0.77 ± 0.07

Decays upstream of MA systematics

Change in selection	Bias in $Re(\epsilon'/\epsilon)$, $\times 10^4$		
	97	99	Combined
$Z > 122.5$ m cut	-0.35 ± 0.27	-0.55 ± 0.17	-0.50 ± 0.16
expected from Z_{ave} change	-0.37	-0.08	-0.20
No MA clearance cut	$+0.52 \pm 0.20$	-0.84 ± 0.13	-0.27 ± 0.10
expected from Z slope change	-0.26	+0.67	

“No MA clearance” cut leads to large problem in upstream Z distribution for 99 data, this could be because of pion scattering/not perfect MA thresholds — not to be taken as systematics but as an illustration of wrong expectation from Z slope change.

Systematic uncertainty for $Re(\epsilon'/\epsilon)$ for combined, subtracting the change expected from average Z change, is 0.38×10^{-4} .

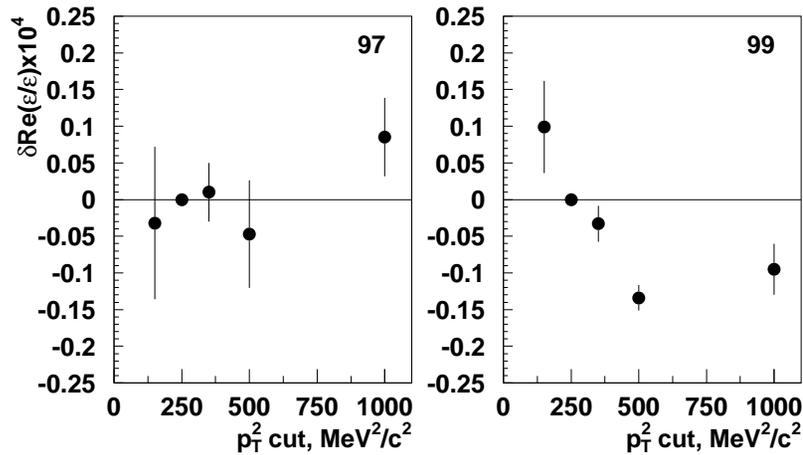
Systematics: L3

- Use B01 random accept events
- Use also B03 (prescale 500) as a cross check — inclusive check of L2 and L3

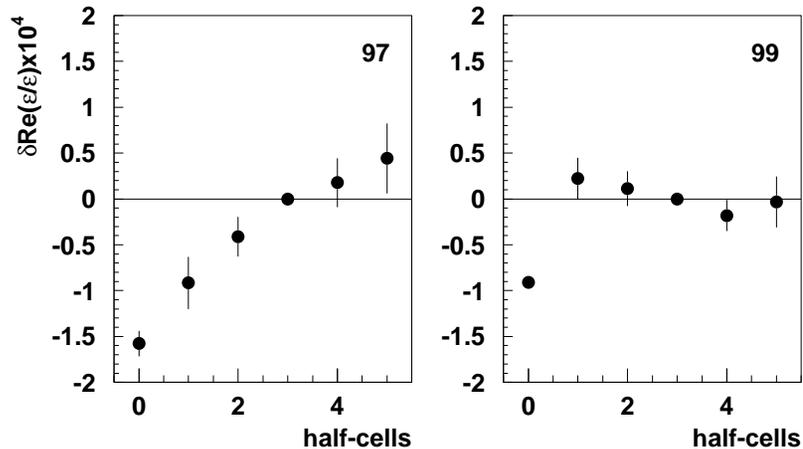
Reference Trigger	Bias in $Re(\epsilon'/\epsilon)$		
	97	99	Combined
B01	0.32 ± 0.20	0.41 ± 0.17	0.37 ± 0.13
B03	0.58 ± 0.59	-0.15 ± 0.63	0.05 ± 0.36

For some reason bias for 97 is smaller compared to PRD, $(0.46 \pm 0.20) \times 10^{-4}$, but this does not change estimated error significantly, 0.42×10^{-4} vs 0.56×10^{-4} . The combined error is 0.43×10^{-4} .

Selection efficiency



Walk vs p_{\perp} is reduced (was about 0.25×10^{-4}) \rightarrow 0.15×10^{-4} uncertainty in $\text{Re}(\epsilon'/\epsilon)$.

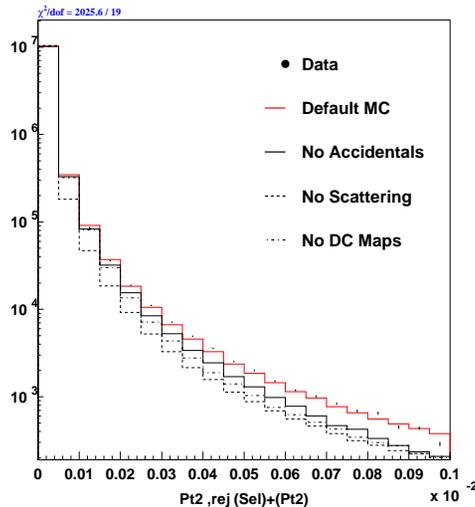


For cell separation cut situation is better for 99, 97 – as for PRD

DC simulation

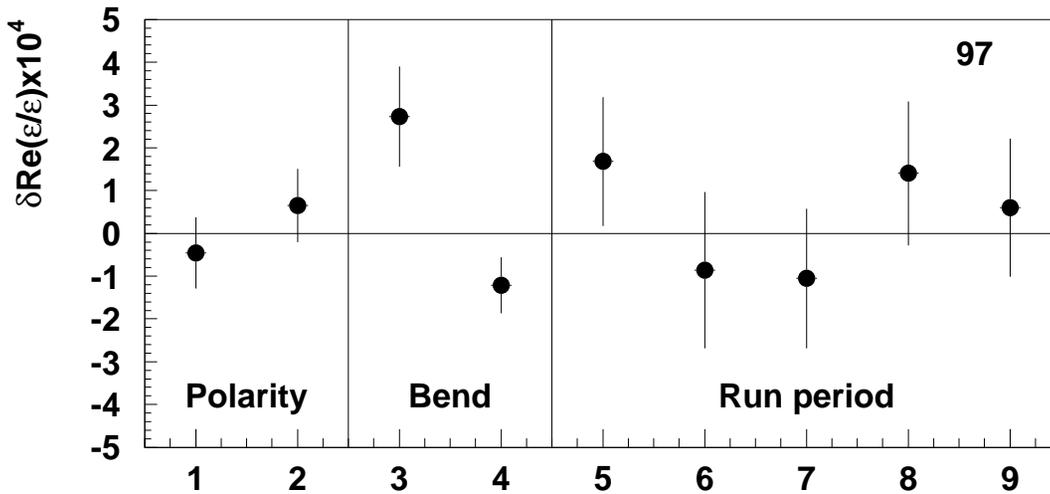
Follow $|V_{us}|$ analysis prescription: generate separate MC with scattering, DC maps, accidental events switched off, take 10% of the change as systematics.

Change of MC simulation	Bias in $Re(\epsilon'/\epsilon)$, $\times 10^4$	
	1997	1999
No Scattering in Spectrometer	+0.19	-0.55
No DC maps	-0.87	-0.31
No Accidental Overlays	0.26	+0.03

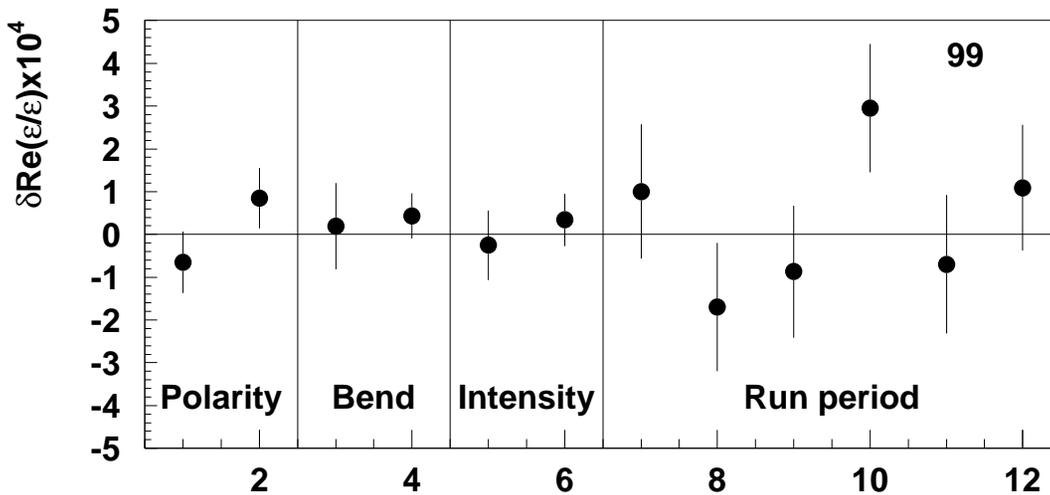


← each of the variations lead to big change in P_{\perp}^2 distribution. Total systematic uncertainty estimated to be 0.15×10^{-4}

Cross checks



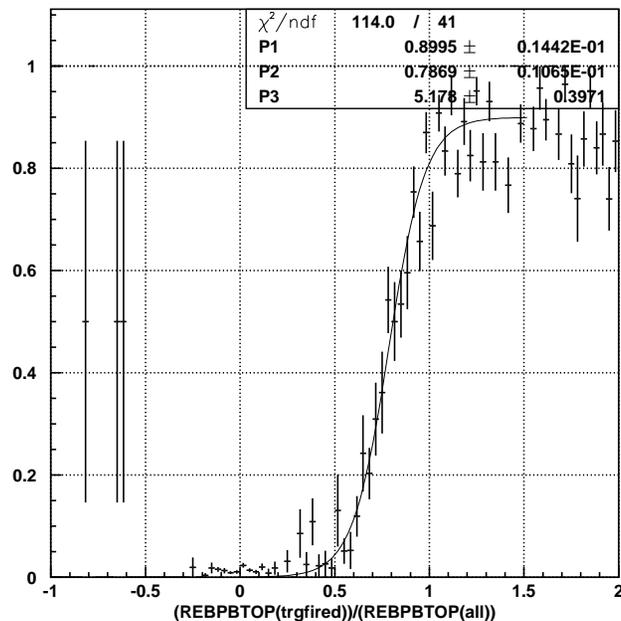
An interesting new test is 99 intensity dependence. Works very well.



Out-/In- bends were not perfect for Jim as well. For 99 — no problem.

Source	Uncertainty $\times 10^{-4}$			
	97 PRD	97	99	Combined
Online selection				
L1 and L2	0.20			
L3	0.54	0.42	0.49	0.43
Track reconstruction				
Alignment and Calibration	0.28	0.20	0.20	0.20
Momentum scale	0.16	0.10	0.10	0.10
Selection efficiency				
p_{\perp}^2 cut	0.25	0.15	0.15	0.15
DC efficiency modeling	0.37	0.15	0.15	0.15
DC resolution modeling	0.15	0.15	0.15	0.15
Apertures				
Wire spacing	0.22	0.22	0.22	0.22
Effective regenerator edge	0.20	0.20	See later	
Z-slope	0.79	0.99	0.30	0.58
Z-upstream	—	0.27	0.46	0.38
Background subtraction	0.20	0.20	0.20	0.20
Monte Carlo statistics	0.41	0.42	0.38	0.28
Total	1.26	1.30	0.98 (?)	1.01 (?)

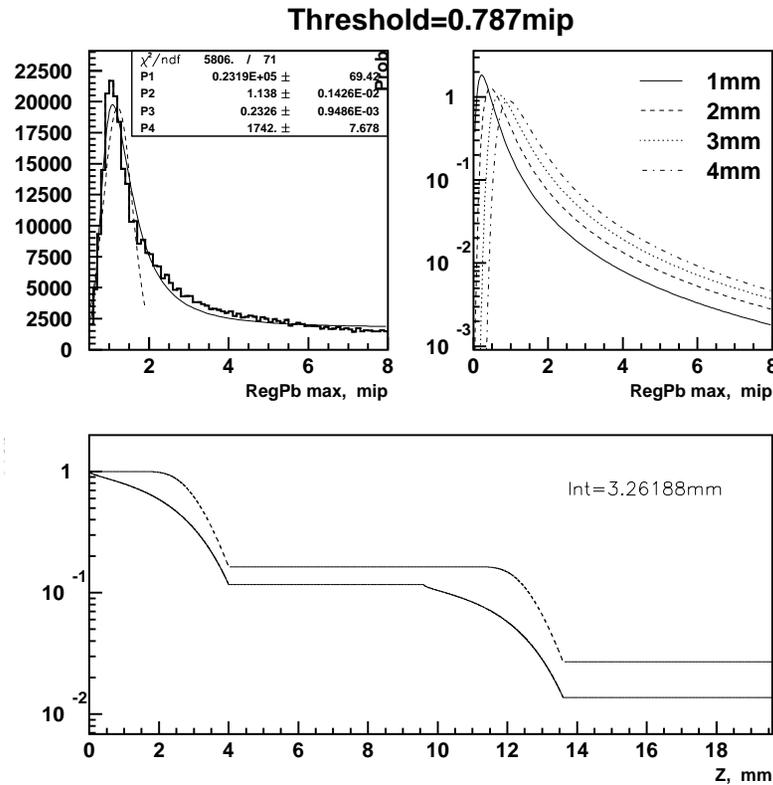
Effective Regenerator Edge – trigger threshold



Effective edge is determined by fraction of $\pi\pi$ events vetoed in the last scintillator module.

- Determine trigger threshold in ADC counts
- Determine response to a MIP particle
- Convolute $K \rightarrow \pi\pi$ production with the reg. veto response.
- Determine systematic uncertainty by varying assumptions.

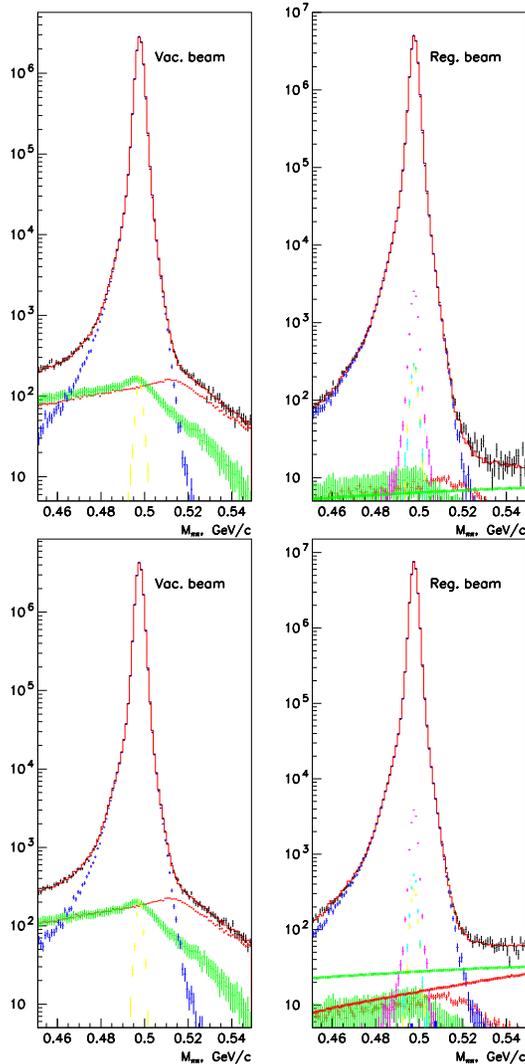
Effective Regenerator Edge – MIP peak, result



Edge position, $Re(\epsilon'/\epsilon)$ uncertainty:

	Edge, mm	$\delta Re(\epsilon'/\epsilon) \times 10^4$
97	1.65 ± 0.45	0.2
99	3.3 ± 1.7	0.75

Edge position: checks



- Worse veto in 99 should lead to larger fraction of “junk” events in regenerator beam.

	97	99
$K^* \rightarrow K^\pm \pi^\mp \times 10^{-5}$	0.18	1.14
$\Delta \rightarrow p\pi \times 10^{-5}$	0.48	1.77
• Z-binned fits with floated reg. edge position.	97	99
$Z_{\text{edge}}, \text{ mm}$	0.96 ± 0.42	5.65 ± 0.35

Reg. edge: plans

Problem has been realized very recently (Thursday evening (HH time)).

Knowledge of the effective edge to about 1/2 of the last scintillator piece is too poor to accept.

- Verify online threshold determination: 99 has used bottom and top phototubes in the trigger.
- Sharpen offline ADC cut from 0.7 to 0.3 – 0.4 “MIP”. Preliminary can reduce junk by 20 – 30%. Check run dependence.
- Bad veto efficiency allows events produced inside **Pb** to get into the analysis sample. Should show as a localized in Z P_t smearing for 99 vs 97 data. Maybe this needs to be included in MC.
- Improve systematics determination: i.e. “Inclusive junk” vs “junk with all veto cuts” should give a better estimate of veto efficiency for $K \rightarrow \pi\pi$ events

Requires some time ...

Z binned fits

Charged mode fits:

	PRD	97	99	97-99
$\Delta m \times 10^5 \hbar s^{-1}$	5266.7 ± 6.4	5266.7 ± 6.5	5268.6 ± 5.4	5267.9 ± 4.2
$\tau_S \times 10^{-12} s$	89.650 ± 0.030	89.650 ± 0.031	89.613 ± 0.026	89.628 ± 0.020
ϕ_{+-}	44.12 ± 0.72	43.86 ± 0.73	43.83 ± 0.61	43.845 ± 0.472

Neutral and combined fits (from Elizabeth's talk):

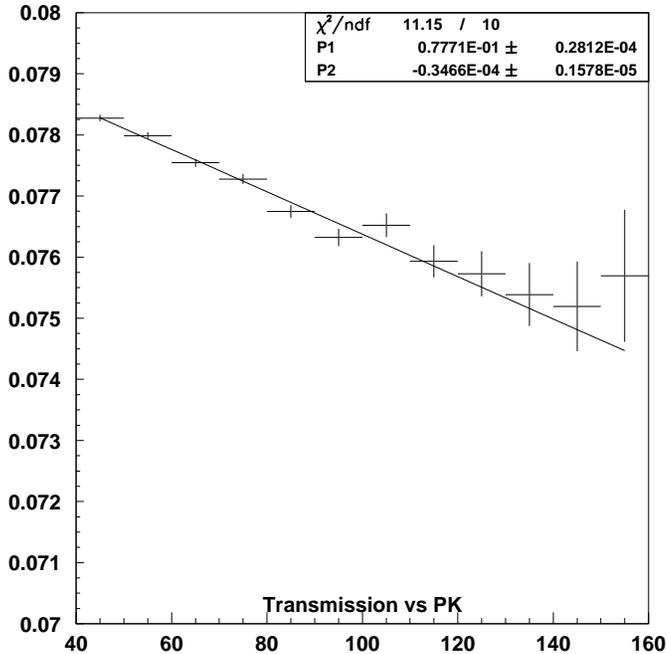
	PRD	97	99	97-99
$\Delta m \times 10^5 \hbar s^{-1}$	5237.3 ± 10.6	5247.6 ± 14.0	5271.8 ± 11.9	5261.6 ± 9.1
$\tau_S \times 10^{-12} s$	89.637 ± 0.050	89.643 ± 0.065	89.715 ± 0.056	89.685 ± 0.043
$Im(\epsilon'/\epsilon)$	-22.9 ± 12.8	-18.5 ± 15.6	-16.1 ± 13.3	-16.6 ± 9.9

(errors include both data and MC stats).

→ improved agreement between charged and neutral mode Δm and τ_S values.

Z binned fits systematics

Z binned fit systematics is improved primary from new attenuation measurement.



	Δm ($\times 10^6 \hbar/s$)	τ_S (10^{-12} s)
PRD analysis	5.2	0.059
PRD fitting	13.3	0.045
NEW fitting	9.7	0.041

Analysis dependent systematic uncertainties are to be summarized ...

Conclusions

Almost ready for a preliminary result.

To be done:

- Regenerator edge in charged mode.
- Putting together CPT fits systematic.
- Finalize documentation.